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Magnetized neutron star atmospheres: Beyond the cold plasma approximation

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Abstract

All the neutron star (NS) atmosphere models published so far have been calculated in the "cold plasma approximation," which neglects the relativistic effects in the radiative processes, such as cyclotron emission/absorption at harmonics of cyclotron frequency. Here, we present new NS atmosphere models which include such effects. We calculate a set of models for effective temperatures T eff = 1-3 MK and magnetic fields B 10 10-1011 G, typical for the so-called central compact objects (CCOs) in supernova remnants, for which the electron cyclotron energy E c, e and its first harmonics are in the observable soft X-ray range. Although the relativistic parameters, such as kT eff/mec 2 and E c, e/mec 2, are very small for CCOs, the relativistic effects substantially change the emergent spectra at the cyclotron resonances, E sE c, e (s = 1, 2, ...). Although the cyclotron absorption features can form in a cold plasma due to the quantum oscillations of the free-free opacity, the shape and depth of these features change substantially if the relativistic effects are included. In particular, the features acquire deep Doppler cores, in which the angular distribution of the emergent intensity is quite different from that in the cold plasma approximation. The relative contributions of the Doppler cores to the equivalent widths of the features grow with increasing quantization parameter b eff ≡ E c, e/kT eff and harmonic number s. The total equivalent widths of the features can reach 150-250 eV; they increase with growing b eff and are smaller for higher harmonics.

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Keywords

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